

From USDA Forest Service
Pinedale Ranger District
P.O. Box 220
Pinedale, WY 82941

Fax Number (307) 739-5750
Office Number (307) 367-4326
FTS Number (307) 739-5700

FAX COVER LETTER

DATE: 2/28/97 TIME: 14:45

TO: Dolly Parker

COMPANY: Solvay Minerals, Environmental
Dept. FAX NO: (307) 872-6510

NUMBER OF PAGES TO FOLLOW: 2

SUBJECT: Deposition → Lake effects

MESSAGE: Dolly, here is what Doug Fox
is now recommending. This is
a screening procedure, as it doesn't
take into account the buffering capacity
of the watershed. If a project failed
this level, the next logical step would
be to run MAGIC which does
account for natural sources of
buffering capacity.

SENT BY: Ann McBane

Screening Model for Calculating ANC Change in Sensitive Lakes

Methodology Revised by Doug Fox

Feb 14, 1997

Background:

The previous version of the lake chemistry screening model assumed that S & N were diluted by a volume of water equal to the entire volume of snow on the watershed and this concentration of strong acid was titrated against an unlimited volume of lake water with its measured ANC. Since the amount of lake water is finite, the amount of available ANC is limited in a way not reflected in the calculation. In addition the size of the watershed must enter into the calculation because a larger watershed would deliver more strong acid to the lake. The relevant parameter is the ratio of the volume of the lake to the area of the watershed. The previous version of the screening model is accurate only in the special case where this value, the Volume of Lake/Area of Watershed is equal to "d" the depth of precipitation. The new equations, described below represent a more accurate screen, and can be used in any case where data is available describing the watersheds, lake volumes and snow melt volumes. In cases where snow melt volume is not known, lake volume divided by flushing time can be used as a reasonable approximation of snow melt volume.

Description:

The formal way the calculation should be done is to: (1) calculate the total loading of S & N on the watershed; (2) estimate the volume of water that this mass of chemical will dissolve in (eg: the volume of snow on the watershed and how much of it melts and when it melts); (3) determine how much of this loading will mix into how much of the lake; (4) consider any natural sources of alkalinity generation in the watershed path that the snowmelt water encounters; and (5) calculate the change of ANC in the lake as a result. The MAGIC model should be considered a more refined approach to make the above determinations; however a screening approach that approximates the above factors is described below.

Calculations:

(1) Determine how much S & N are deposited:

Estimate annual deposition by multiplying the concentration produced by the model by an annual "deposition velocity". This will estimate the dry deposition loading on the watershed. Wet deposition can either be estimated from wet deposition measurements (e.g. NADP) or by assuming wet deposition is equal to some percentage of dry deposition. Based on western U.S. deposition data, it is reasonable to assume that wet and dry deposition are equal. For this screening procedure, use deposition velocity on the order of 1.0 cm/sec for NO₂ and 2.5 cm/sec for SO₂. This will result in a loading of S and N on the watershed in units of kg/ha for a year (or snow accumulation cycle). Multiply this by the watershed surface area to determine the total loading on the watershed.

(2) Determine how much water is available for the S & N to mix with:

Use the amount of S & N deposited (ie: the number of H ions deposited), which is the $S \text{ (eq/m}^2\text{)} \times A \text{ (m}^2\text{)} + N \text{ (eq/m}^2\text{)} \times A \text{ (m}^2\text{)}$. The H ion then titrates the H available in the lake water, the ANC (eq/m^3) \times volume of lake water (m^3).

(3) Calculate the change in pH or in ANC.

Since pH and ANC are concentrations, the resulting number of equivalents needs to be divided by the volume of water. Where it can be assumed that the snowmelt runoff is small compared to the volume of water in the lake, the new ANC = $ANC - (S + N) \times A/V$. The equation I suggested in 1983 and that people have been using is then correct only if d is interpreted as the Volume of the Lake/Area of the watershed, not the amount of precipitation. Where the volume of the snowmelt is known, the calculation is $\text{newANC} = (ANC \times V_{\text{lake}} - (S + N) \times A) / (V_{\text{lake}} + V_{\text{snowmelt}})$. All the conversion factors to from kg of S & N to equivalents and the arithmetic to calculate logs would carry over.

(4) Determine what would happen in subsequent years of deposition:

In order to be consistent with the calculation, the calculation should be repeated for each year. If we assume, as a worst case estimate that there are no internal sources of alkalinity, then simply repeat the calculation for each year, reducing the ANC accordingly each year. I think this is a very conservative assumption, but in the absence of detailed lake chemistry modeling, this seems like a reasonable suggestion.

For questions or further information, call or write:

Doug Fox
International Air and Natural Resources Management
Senior Research Scientist
Cooperative Institute for Research in the Atmosphere (CIIRA)
Colorado State University
1517 Linden Lake Road
Fort Collins, CO 80524 USA
970-221-0800 nor 970-491-3983
FAX 970-224-5023
dfox@cira.colostate.edu